This document includes the Steel, Composite, and Other Non-Aluminum Rigid Hulls in the EPA "Draft Characterization Report for Hull Coating Leachate" published in August 2003. The reference number is: EPA842-D-06-001

DRAFT
Characterization Report
Hull Coating Leachate

Steel, Composite, and Other Non-Aluminum Rigid Hulls, Baseline Discharge, Copper Release Rates, Foul-Release Coatings, and Advanced Antifouling Coatings.

August 2003

2.0 STEEL, COMPOSITE, AND OTHER NON-ALUMINUM RIGID HULLS

The Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group is the largest group of the three selected vessel groups for this discharge. This vessel group contains over 2,600 vessels, which is approximately 85% (by number) of all Armed Forces vessels that produce the hull coating leachate discharge. The total underwater hull wetted area for this vessel group is 2.5×10^7 ft^2, which is 91% of the total underwater hull wetted area for all Armed forces vessels that contribute to this discharge.

The vessels in the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group range from boats less than 55 feet in length to aircraft carriers that are more than 1000 feet long. Although vessels in this group vary considerably in size and design, they primarily use copper-containing antifouling coatings. The USS NIMITZ (CVN 68) class was selected as the vessel class on which to conduct analyses for this group because aircraft carriers have the largest underwater hull surface area of any Armed Forces vessel and produce the greatest constituent mass loading. In addition, the CVN 68 class is representative of the larger Navy ships that are extending their drydocking cycles from 5-7 years to approximately 12 years.

2.1 BASELINE DISCHARGE

Vessels in this group use one of several similar copper-containing hull coatings that release copper into the water as a result of cuprous oxide particle dissolution. To ensure a constantly refreshed supply of cuprous oxide particles at the coating surface, the overall paint system ablates or wears away. These coatings have a relatively long service life when compared to other coatings (i.e., foul-release and advanced antifouling coatings) and are the only currently available coatings capable, with supplementary hull cleanings, of supporting a 12-year drydocking cycle. These coatings are durable and can be used on all vessels types except vessels with aluminum hulls.

The baseline discharge for this vessel grouping includes constituents from the copper ablative antifouling coatings qualified to military specification MIL-PRF-24647, vinyl antifouling coatings manufactured to military specification MIL-P-15931, or the ablative coatings specified in contracts for use on Armed Forces vessels (e.g., Military Sealift Command vessels use copper ablative coatings not qualified to Navy specifications). Vessels in this group typically use the following copper-containing antifouling coating systems:

- Ameron ABC #3,
- International BRA640,
- Ameron ABC #4,
- Hempel Olympic 7660, and
- International 4050 (i.e., vinyl antifouling coating, Formula 121 of MIL-P-15931).

It is estimated that 86% of the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group is coated with a copper ablative antifouling coating (i.e., ABC #3, BRA640, ABC #4, and

Olympic 7660) and 14% is coated with vinyl antifouling coatings (i.e., Formula 121) (Shimko and Tock, 2003). Ameron ABC #3 and International BRA640 are the most predominately used and studied copper ablative antifouling coatings. It is assumed that 50% of vessels using copper ablative coatings are coated with Ameron ABC #3 and the remaining 50% are coated with International BRA640. To facilitate estimations for a fleet coated with two different coatings, the constituent information from each of the two coatings were averaged and the average information was used to serve as the baseline coating information in the analyses. The remaining 14% of vessels are coated with vinyl antifouling coatings (i.e., Formula 121). Information on the other hull coatings used by the Armed Forces was collected and is included in Appendix A.

2.1.1 Characterization Data

Hull coating leachate discharge is the result of constituents being released from antifouling coatings. Studies conducted by the Navy and information supplied by coating manufacturers were used to characterize these coatings and the resulting discharges.

2.1.1.1 Physical Parameters

The CVN 68 class hull is steel as are the majority of the hulls of the vessels in this vessel group. The CVN 68 class currently includes ten vessels. Each vessel is 1,040 ft long and has an underwater hull area of 159,500 ft^2 (Navy, 1992). CVN 68 class vessels are in U.S. ports for an average of 147 days per year and in transit between 0 nm and 12 nm of the U.S. shoreline approximately three days per year (EPA and Navy, 1999).

2.1.1.2 Constituent Data, Classical Data, and Other Descriptors

Chemical Data

<u>Composition of Coatings</u>

The initial step taken to characterize the hull coating leachate discharge was to identify constituents present in the coatings and their relative quantities. MSDSs were obtained for each coating in this option group. MSDSs do not list all coating constituents, but all biocides and hazardous materials are required by law to be reported by the coating manufacturer. Therefore, only constituents listed in each coating's MSDS are addressed. MSDS reporting requirements permit the ingredient quantities to be listed as a possible range or a maximum value to protect a company's confidentiality. Some of the coatings' MSDSs reported a maximum value for the constituent information and the maximum value was used for the constituent weight percentage.

As previously stated, 86% of vessels in the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group are coated with copper ablative coatings. The two most commonly used coatings are Ameron ABC #3 and International BRA640. The MSDS constituent information for Ameron ABC #3 and International BRA640 is presented in Tables 2-1 and 2-2, respectively.

Table 2-1. Constituents for Ameron ABC #3 (Red)

Constituent	Approximate Coating Weight % from MSDS
Cuprous oxide	50
Zinc oxide	20
Butyl alcohol	9.7
Xylene	5.9
Polyamide resin	5.0
Plasticizer	5.0
Ethyl benzene	1.4

Source: Ameron MSDS for ABC #3 (Ameron, 2002a).
-The MSDS reported the weight percentage to be is less than or equal to these values.

Table 2-2. Constituents for International BRA640 (Red)

Constituent	Approximate Coating Weight % from MSDS
Cuprous oxide	38
Zinc oxide	18
Rosin	18
N-butyl alcohol	5.5
Ethyl benzene	5.5
Iron oxide	5.5
Xylenes (o-, m-, and p- isomers)	5.5
N-ethyltoluenesulfonamide (plasticizer)	5.5

Source: International MSDS for BRA640 (Red) (International, 2002a).
- The MSDS reported a weight percentage range. The constituent weight percentage presented in the table is the midpoint of the range.

The constituent values from ABC #3 and BRA640 were averaged to generate constituent information for the baseline copper ablative coating that is shown in Table 2-3 (refer to section 2.1 for assumptions and reasoning). The plasticizers used by ABC #3 and BRA640 were identified by different Chemical Abstracts Service (CAS) Registry numbers. Therefore, these constituents remain identified as separate entities in Table 2-3.

Table 2-3. Constituents for the Baseline Copper Ablative Coating in the Steel, Composite, and Other Non-Aluminum Rigid Hulls Vessel Group

Constituent	Estimated Weight % in Baseline Coating
Cuprous oxide	44
Zinc oxide	19
Rosin	8.8
N-butyl alcohol	7.6
Xylenes (o-, m-, and p- isomers)	5.7
Ethyl benzene	3.5
N-ethyltoluenesulfonamide (plasticizer)	2.8
Iron oxide	2.8
Polyamide resin	2.5
Plasticizer	2.5

The remaining 14% of vessels in the Steel, Composite, and Other Non-Aluminum Rigid Hulls vessel group use vinyl antifouling coatings to coat hulls. These coatings are not ablative, but release copper slowly by leaching through a porous matrix that is produced by hydrolysis of rosin. Table 2-4 presents the MSDS constituents listed for vinyl antifouling coatings (i.e., Formula 121).

Table 2-4. Constituents for Vinyl Antifouling Coatings (i.e., Formula 121)

Constituent	Approximate Coating Weight % from MSDS
Cuprous oxide	63
Rosin	18
Methylisobutyl ketone	5.5
Xylenes (o-, m-, and p- isomers)	5.5
N-ethyltoluenesulfonamide (plasticizer)	5.5
vinyl chloride-vinyl acetate copolymer	5.5
Ethyl benzene	0.6

Source: MSDS for International 4050 (International, 2002c).
- The MSDS reported a weight percentage range. The constituent weight percentage presented in the table is the midpoint of the range.

Constituent Release Rates

In 1997, the Navy's Marine Environmental Support Office (MESO) reported test results of panels painted with the copper ablative coatings, ABC #3 and BRA640, conducted in San Diego Bay over a period of three to five years. Static testing was conducted using stationary steel panels to simulate pierside conditions. As part of the static test procedure (Lindner, 1993), 10 by 12 inch steel panels were coated on both sides with the test paints. These panels were then inserted vertically into PVC frames and suspended from the floating platform 3 feet below the water surface for a 2 or 3 month period. Rotating steel drums were used for dynamic testing to simulate underway conditions. Copper ablative coatings were applied to both sides of the 3 by 7 inch steel panels (88 steel panels per drum). The steel panels were then attached to a plastic drum 18 inches in diameter by 36 inches long and immersed in seawater 3 feet below the water surface. The drum was then mechanically rotated at a peripheral velocity of 17 knots to simulate ship movement through water. One month of rotating the drums in a dynamic cycle was followed by a one month static (stationary) cycle. After 39 months, the test protocol was changed to two months of static and one month of dynamic exposure. Release rates for copper and zinc were generated from this study (MESO, 1997; EPA and DoD, 1998).

Using the release rates from the MESO report and MSDS constituent information, the release rates for all constituents listed in the baseline coating were estimated. For solvents, the volatile organic compounds (VOCs) used in the coating (e.g. xylene, butyl alcohol, etc.) act as simple carriers and are assumed to evaporate out of the coating before the vessel is placed in the water. This assumption is valid for antifouling coatings because the purpose of the solvent is to reduce coating viscosity such that the coating can be applied (i.e., typically by spray, brush, or roller). The coating "dries" based on simple solvent evaporation (i.e., there are no chemical reactions involving the solvents). Antifouling coatings are allowed to air dry for at least 24 hours before a ship is placed in the water. This time period allows solvent evaporation out of the coating and minimizes the amount of solvent that could be released into the water. The assumptions related to biocide release rates are based on the inherent consistency of the coating and coating ablation rate. Because the ratio of the copper and zinc-containing compounds in an ablative coating are consistent throughout the coating thickness and the coatings ablate, or decrease in thickness, at a uniform rate, the release rate of the copper and the zinc compounds is assumed to be directly related to the ratio of the weight percentages of these compounds in the coating. For example, if an ablative coating contained twice as much copper by weight than zinc, the release rate of copper would be assumed to be twice the release rate of the zinc. The use of these ratios resulted in following formula:

$$\textit{Constituent (A) Release Rate} = \left(\frac{Constituent\ (A)\ wt\,\%}{Copper\ wt\,\%} \right) \times Copper\ Release\ Rate$$

Calculations were performed using the dry weight composition of the coating (i.e., removing the solvent quantities when calculating the constituent weight percentage). The estimated release rates for constituents in the baseline copper ablative coating are listed in Table 2-5. The ablative coatings and vinyl antifouling coatings (i.e., Formula 121) release constituents as dissolved metallic species and as particulates (e.g., a "chunk" of antifouling paint dislodges as the result of ablation). Therefore, release rates are measured as total metals through analytical testing and are presented as such for all release rate data presented in the ChAR.

Table 2-5. Static and Dynamic Release Rates for the Baseline Copper Ablative Coating

Constituent Name	Dynamic Release Rate [(µg/cm^2)/day]	Static Release Rate [(µg/cm^2)/day]
Total Copper	17[a]	8.9[a]
Total Zinc	6.7[a]	3.6[a]
Rosin	3.8	1.6
N-ethyltoluenesulfonamide (plasticizer)	1.2	0.52
Polyamide resin	1.1	0.47
Plasticizer	1.1	0.47
Total Iron	0.84	0.44
N-butyl alcohol[b]	0.0	0.0
Xylenes (o-, m-, and p- isomers)[b]	0.0	0.0
Ethyl benzene[b]	0.0	0.0

[a]-Source: 1997 MESO Study (MESO, 1997).
[b]-VOCs are estimated to not be present in the cured coating.

Although vinyl antifouling coatings are not ablative, the release rates were estimated using the equation shown previously. Vinyl antifouling coatings are not amenable to the existing test methods for estimating release rates from ablative coatings. Studies using ablative-type methods have produced widely varied results. In 1999, the *European Coatings Journal* published average total copper release rates for vinyl antifouling coatings ranging from 2 to 202 µg/cm^2/day (Arias, 1999). The total copper release rate estimated for vinyl antifouling coatings from the previously stated equation is in the published range and is present in Table 2-6 along with constituents in vinyl antifouling coatings.

Table 2-6. Static and Dynamic Release Rates for Vinyl Antifouling Coatings

Constituent Name	Dynamic Release Rate [(µg/cm^2)/day]	Static Release Rate [(µg/cm^2)/day]
Total Copper	22	12
Ethyl Benzene[a]	0.0	0.0
Methylisobutyl Ketone[a]	0.0	0.0
Xylenes (o-, m-, p- isomers)[a]	0.0	0.0
N-Ethyltoluenesulfonamide (plasticizer)	2.2	1.1
Rosin	6.9	3.7
vinyl Chloride-vinyl Acetate Copolymer	2.2	1.1

[a]-VOCs are estimated to not be present in the cured coating.

In 2002, the MESO conducted another study to provide copper release rates for International BRA640. During this study, seawater samples were gathered at varying distances from the hull of the USS RENTZ (FFG 46) and analyzed to determine total and dissolved copper concentrations. FFG 46 was coated with BRA640 and a number of small (10’x10’) test patches of advanced antifouling coatings. These patches are relatively small and are distributed along the hull. Sampling locations were selected such that the measurements near the hull were generated aft of the test patches and adjacent to the Navy approved BRA640 antifouling coating. Three replicate samples were collected at each sampling location of 1 cm, 10 cm, 1 m, 10 m, and 80 m from the hull (MESO, 2002). A geometric mean was calculated for each set of replicate samples at each distance. The FFG 46 data are presented in Table 2-7. According to MESO, the 80 m value of 4.7 µg/l is in the range of background measurements within the Naval station pier areas.

Table 2-7. USS RENTZ (FFG 46) Total Copper Data

Distance from Hull	Geometric Mean of Total Copper Concentration (µg/l)
1 cm	10
10 cm	7.3
1 m	6.0
10 m	4.3
80 m	4.7

Source: 2002 MESO Study (MESO, 2002).

Recognizing the reduction in concentration with distance from the hull is fundamentally a diffusion phenomena, solutions to basic diffusion equations were evaluated for correlation with the Table 2-7 data. The equation showing the highest correlation to the FFG 46 data points is a simplified derivation of the Streeter-Phelps equation (Benoit, 2002):

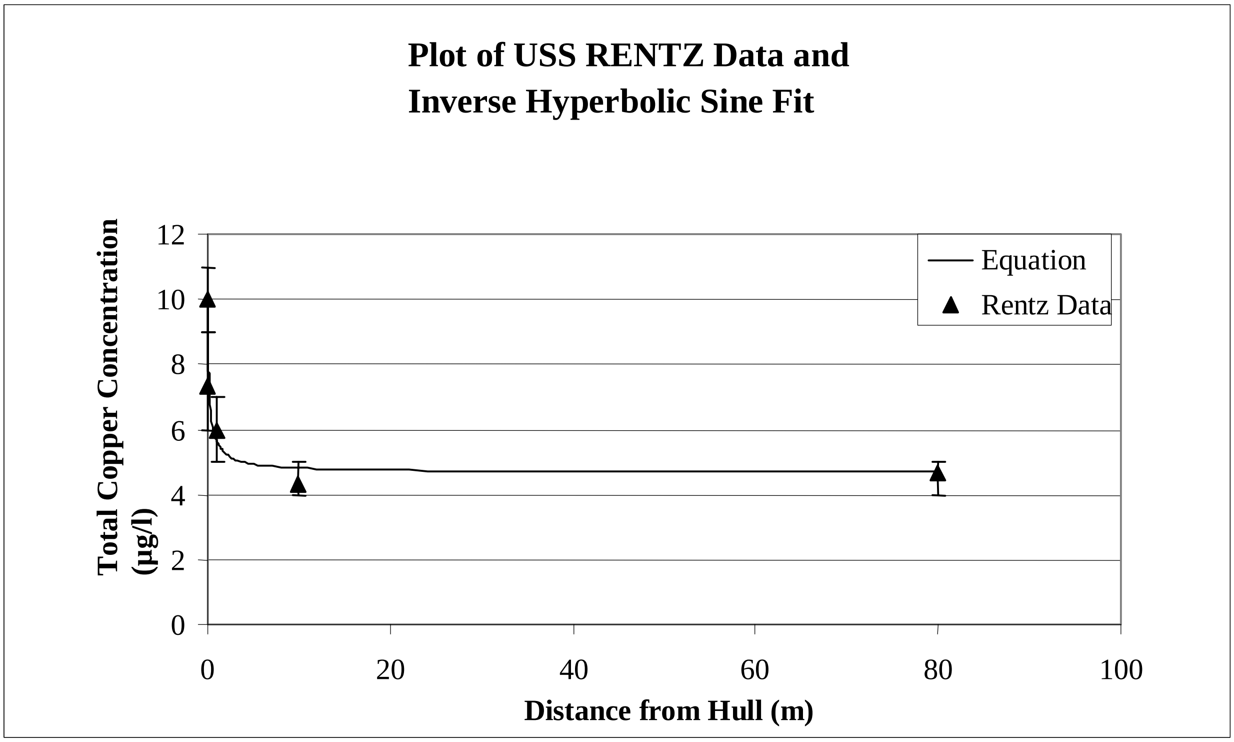
$$y = 1.4 \sinh^{-1}\left(\frac{1.2}{x}\right) + B$$

where:

y = Concentration in µg/l,
x = Distance from the hull in meters (for x>0.01 m), and
B = Background Concentration in µg/l (i.e., 4.7µg/l).

Figure 2-1 shows the USS RENTZ (FFG 46) data and the plot of the equation shown above.

Figure 2-1. USS RENTZ Total Copper Data



The equation is used to calculate concentrations at 1 cm and 35 m from the hull for the environmental effects analyses. The concentration at 1 cm is used for the end-of-pipe analysis. The concentration at the 35 m edge of the mixing zone is used to perform the discharge toxicity calculations.

To estimate the concentration of other identified constituents at 1 cm and 35 m, an assumption was made that the static release rate of a constituent corresponds to a concentration at a specific distance with the following equation:

$$Concentration\ at\ X\ m = \left(\frac{Copper\ Conc.\ at\ Xm}{Copper\ Static\ Release\ Rate} \right) \times Constituent\ Static\ Release\ Rate$$

The constituent concentrations at 1 cm and 35 m from the hull for copper ablative coatings and vinyl antifouling coatings are calculated using the above equation and are listed in Tables 2-8 and 2-9, respectively.

Table 2-8. Concentration of Constituents Released from Copper Ablative Coatings

Constituent Name	Concentration with Removal of Background Level (µg/l)	
	1 cm	35 m
Total Copper	5.3	$3.3x10^{-2}$
Total Zinc	2.1	$1.3x10^{-2}$
Rosin	1.0	$6.1x10^{-3}$
N-ethyltoluenesulfonamide (plasticizer)	0.31	$1.9x10^{-3}$
Polyamide resin	0.28	$1.7x10^{-3}$
Plasticizer	0.28	$1.7x10^{-3}$
Total Iron	0.26	$1.6x10^{-3}$
N-butyl alcohol[a]	0.0	0.0
Xylenes (o-, m-, and p- isomers)[a]	0.0	0.0
Ethyl benzene[a]	0.0	0.0

[a]-VOCs are estimated to not be present in the cured coating.

Table 2-9. Concentration of Constituents Released from Vinyl Antifouling Coatings

Constituent Name	Concentration with Removal of Background Level (µg/l)	
	1 cm	35 m
Total Copper	6.8	$4.3x10^{-2}$
Ethyl Benzene[a]	0.0	0.0
Methylisobutyl Ketone[a]	0.0	0.0
Xylenes (o-, m-, p- isomers)[a]	0.0	0.0
N-Ethyltoluenesulfonamide (plasticizer)	0.68	$4.3x10^{-3}$
Rosin	2.2	$1.4x10^{-2}$
Vinyl Chloride-vinyl Acetate Copolymer	0.68	$4.3x10^{-3}$

[a]-VOCs are estimated to not be present in the cured coating.

Field Information

Field information for coatings in the baseline discharge was not generated as part of the UNDS data collection process.

Descriptive Information

Descriptive information is not available for coatings in the baseline discharge. As previously stated, hull coating leachate is not discharged from a pipe but slowly released from the entire underwater hull of a vessel. Due to the rate and nature of the constituents released, this discharge is expected to have negligible affects on parameters related to narrative water quality criteria. In addition, constituent concentrations at the 35 m edge of mixing zone are shown to approach background levels. Therefore, it is deduced that antifouling coatings do not produce a meaningful effect on color, floating materials, odor, settleable materials, taste, or turbidity/colloidal matter in receiving waters.

2.1.1.3 Discharge Generation Rates for Mass Loading

The mass loading rates are estimated for the ten vessels that are listed in the CVN 68 class. A complete list of Steel, Composite, and Other Non-Aluminum Rigid Hulls vessels is included in the *Vessel Grouping and Representative Vessel Selection for Hull Coating Leachate Discharge* (EPA and Navy, 2003c). To calculate generation rates for the vessel class, all ten CVN 68 class vessels were considered. Static release rates were used for in port estimates and dynamic release rates were used for underway estimates. Only total copper and total zinc generation rates are presented because these are the only constituents of concern in currently approved, copper-containing antifouling coatings. Total copper and total zinc generation rates are calculated assuming an 86% use of the baseline copper ablative coating and a 14% use of vinyl antifouling coatings. Tables 2-10 and 2-11 present the estimated generation rates for total copper and total zinc, respectively, for the CVN 68 vessel class. A full listing of vessel classes and characteristics for calculating generation rates and mass loadings are included in Appendix B.

Table 2-10. CVN 68 Vessel Class Estimated Generation Rates for Total Copper

Class	Number of Vessels	Days In Port	Days in Transit (0-12 nm)	Days Underway (12+ nm)	Daily generation rate per vessel (kg Cu/day)			Annual generation rate per class (kg Cu/year)		
					In Port	Underway (0-12 nm)	Underway (12+ nm)	In Port	Underway (0-12 nm)	Underway (12+ nm)
CVN 68	10	147	3	215	1.4	2.7	2.7	$2.1x10^3$	81	$5.8x10^3$

Note: This analysis includes the CVN 76 and CVN 77, neither of which is commissioned. The calculation does not account for a vessel's time in drydock.

Table 2-11. CVN 68 Vessel Class Estimated Generation Rates for Total Zinc

Class	Number of Vessels	Days In Port	Days in Transit (0-12 nm)	Days Underway (12+ nm)	Daily generation rate per vessel (kg Zn/day)			Annual generation rate per class (kg Zn/year)		
					In Port	Underway (0-12 nm)	Underway (12+ nm)	In Port	Underway (0-12 nm)	Underway (12+ nm)
CVN 68	10	147	3	215	$4.5x10^{-1}$	$8.5x10^{-1}$	$8.5x10^{-1}$	$6.7x10^2$	26	$1.8x10^3$

Note: This analysis includes the CVN 76 and CVN 77, neither of which is commissioned. The calculation does not account for a vessel's time in drydock.

2.1.2 Uncertainty Information

Uncertainty exists in the estimation of release rates for coating constituents. The copper and zinc release rates obtained from a MESO report were based on testing conducted in San Diego Bay. Release rates have been shown to be affected by a variety of factors (e.g., temperature, pH, age of coating) (Lindner, 1993). Therefore, the release of copper and zinc is expected to vary with these factors.

A second source of uncertainty is introduced when estimating the release rates of other coating constituents. The release rates for other coating constituents were estimated based on their weight percentage relative to copper. The assumption that release rates are proportional to coating composition has not been verified. Further, the weight percentage was estimated, based on MSDS information, for each constituent. In many cases, MSDSs only listed a range and not a specific value for a particular constituent. In some cases, a maximum value of the range was used, while in other cases, the midpoint of the range was used.

2.2 ESTABLISH A MAXIMUM ALLOWABLE COPPER RELEASE RATE FOR ANTIFOULING COATINGS

This MPCD option group is similar to the baseline discharge. Additional characterization and calculations are not necessary. As described in Section 2.1, static and dynamic field testing was used to characterize the discharge from the "Establish a Maximum Allowable Copper Release Rate for Antifouling Coatings" MPCD.

A numerical maximum allowable copper release rate standard would be based on the results of ongoing Navy testing using the American Society for Testing and Materials (ASTM) D 6442, *Standard Test Method for Copper Release Rates of Antifouling Coating Systems in Seawater*, a laboratory test method. The laboratory copper release rate values generated using the ASTM D 6442 test method do not correlate with the measured field release rates from the FFG 46 hull studies. The ASTM D 6442 test method specifically states "This test method has not yet been validated to reflect in-situ copper release rates for antifouling products and therefore should not, at present, be used in the process of generating environmental risk assessments. In-service release rates of antifouling coatings are expected to vary with natural variability in seawater chemistry, temperature, and hydrodynamic regime" (ASTM, 2000). The ASTM D 6442 test method was developed as a laboratory test method to rapidly produce data that could be used to compare copper release rates from similar coating systems. The ASTM test method uses closely controlled temperatures, pHs, and other test parameters such that reproducible results used for qualification and registration of antifouling products are generated. The ASTM test method was never intended to reflect the actual copper leach rate from coatings on ships for multi-year periods in waters with widely varying pH, temperature, and salinity. Thus, the ASTM D 6442 test method copper release rate results cannot be compared with the observed field release rates from the FFG 46.

2.3 FOUL-RELEASE COATINGS

Foul-release coatings form smooth, low-surface energy layers on a ship hull that inhibits the ability of fouling organisms to adhere to the hull (NRL, 1997). These systems control fouling by using the shearing forces created when a vessel moves through the water to dislodge fouling organisms from the hull. Foul-release coatings do not release biocides into the water and, consequently, can foul if a ship remains inactive for an appreciable period. As little as two weeks of vessel inactivity in areas that experience rapid growth of fouling organisms can result in the build-up of marine growth on a hull coated with a foul-release coating (International, 2001). If fouling organisms are not dislodged as a result of normal vessel operations, the foul-release coatings can be cleaned using soft brushes or rags. Unfortunately, even the most careful cleaning of the soft, foul-release coatings can result in coating scratches and damage exposing the epoxy coating system primer. Once a scratch exposes the epoxy primer or the hull substrate, fouling organism grow in these areas during periods of vessel inactivity and cannot be dislodged without using aggressive brushing or scraping. The aggressive brushing or scraping then creates more scratches and the functionality of the foul-release coating rapidly degrades. The net effect of these scratch/cleaning cycles is rapid degradation in the performance of the foul-release coating. Experience on Navy and USCG craft indicate the service life of a foul-release coating is three years or less, which is a major impediment to widespread use of foul-release coatings. For additional information about foul-release coatings, see the *Hull Coating Leachate MPCD Screen, MPCD Option Group: Foul-Release Coatings*, and the *Feasibility Impact Analysis Report: Hull Coating Leachate* (EPA and Navy, 2003b; EPA and Navy, 2003d).

2.3.1 Characterization Data

Characterization of foul-release coatings and the resulting leachate is presented in the following sections. The only foul-release coating approved for use on Armed Forces vessels is International Intersleek 425. Information supplied by the manufacturer and the U.S. Environmental Protection Agency (EPA) regarding composition of the material are used as the basis for this analysis (International, 2002c; EPA, 1985).

2.3.1.1 Physical Parameters

The physical parameters of the vessel group do not change among MPCD option groups. The CVN 68 class physical parameters are presented in Section 2.1.1.1.

2.3.1.2 Constituent Data, Classical Data, and Other Descriptors

Chemical Data

The coating constituents for International Intersleek 425 are presented in Table 2-12.

Table 2-12. Constituents for International Intersleek 425

Constituent[a]	Approximate Coating Weight % from MSDS[a]
Ethyl benzene	11
Titanium dioxide	11
Xylenes (o-, m-, and p- isomers)	11

[a]Source: International Intersleek 425 MSDS (Intersleek, 2002c).
- The MSDS reported a weight percentage range. The constituent weight percentage presented here is the maximum value.
- The MSDS did not report information regarding the balance of constituents. The remaining percentage of coating constituents may include silicon, resins, oils, pigments, and fillers.

Information from International Coatings and EPA letters regarding registration of the Intersleek 425 product indicates that none of the constituents identified in Table 2-12 are released into the water. For example, International Coatings referenced a letter from the EPA that states EPA registration was not necessary for this particular coating because "the paint acts solely through a physical or mechanical means" (EPA, 1985). Foul-release coatings are exempt from reporting under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Public Law 95-396), because no biocides are used to control biofouling. The release of any other constituents that may be present in Intersleek 425 is expected to be negligible. As previously stated for copper-containing coatings, the solvent included in the constituent list is released during the application and curing of the coating.

Field Information

Field information for foul-release coatings is not required and was not generated as part of the UNDS program.

Descriptive Information

Descriptive information was not collected as part of the UNDS program for foul-release coatings. Due to the rate and nature of the constituents released, this discharge is expected to have negligible affects on parameters related to narrative water quality criteria (i.e., descriptive information).

2.3.1.3 Discharge Generation Rates for Mass Loading

The release rates of constituents from International Intersleek 425 are estimated to be negligible. Therefore, generation rates for this coating are assumed to be zero.

2.3.2 Uncertainty Information

Foul-release coatings are not designed to release constituents and do not contain biocides. No studies have been conducted identifying or quantifying constituents released from foul-release coatings.

2.4 ADVANCED ANTIFOULING COATINGS

Virtually all major marine-paint vendors market an advanced antifouling coating that contains copper and some form of non-metallic biocide. The advanced antifouling coatings are expected to replace TBT-based paints on commercial ships in advance of the International Maritime Organization’s proposed prohibition on the use TBT-based antifouling paints by 2008 (IMO, 2003).

Given the high level of commercial interest in advanced antifouling coatings, there are numerous formulations containing metallic and non-metallic biocides. For the purpose of this analysis, only the advanced antifouling coating approved for use by the USCG will be evaluated. The USCG has approved one advanced antifouling coating, *E Paint SN-1*, for use on smaller USCG aluminum hulled vessels. *E Paint SN-1* contains zinc oxide and the patented non-metallic biocide Sea-Nine211®.

2.4.1 Characterization Data

Characterization of advanced antifouling coatings and the resulting discharge is presented in the following sections. The advanced antifouling coating *E Paint SN-1* is the basis for all calculations. Information supplied by both the E Paint Company and the EPA is the basis for all the analyses.

2.4.1.1 Physical Parameters

The physical parameters of the vessel group do not change among MPCD option groups. The CVN 68 class physical parameters are presented in Section 2.1.1.1.

2.4.1.2 Constituent Data, Classical Data, and Other Descriptors

Chemical Data

Composition of Coating

The coating constituents for *E Paint SN-1* are presented in Table 2-13.

Table 2-13. Constituents for E Paint Company *E Paint SN-1*

Constituent[a]	Approximate Coating Weight % from MSDS[a]
Zinc oxide	36
Ethyl benzene	21
Sea-Nine211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one)	3.0
Xylene	1.9
Toluene	1.2

[a]Source: E Paint Company MSDS for *E Paint SN-1* (E Paint, 2002).
- The MSDS did not report information regarding the balance of constituents. The remaining percentage of coating constituents may include silicon, resins, oils, pigments, and fillers.

Constituent Release Rates

The E Paint Company supplied the release rate for Sea-Nine211® (EPA, 2001) but did not provide release rates for other constituents. The E Paint Company claims that the Sea-Nine211® biocide in this coating is released by chemical reaction with seawater and is not dependent on ship motion to polish or ablate the material. Therefore, dynamic and static release rates are not applicable. Further, E Paint Company indicated that no other constituent is an active ingredient and that the zinc oxide is a pigment encased in the coating and is not released (E Paint, 2003a). EPA considers zinc oxide to be a biocide in this formulation . Based on the latest *E Paint SN-1* product data sheet, the *E Paint SN-1* coating is considered a copper and tin-free ablative matrix vehicle coating (E Paint, 2003b). Given the different explanations and terms associated with the functionality of the *E Paint SN-1*, the Navy reviewed panel test data from this coating (Lawrence, 2003). The waterline test panel data indicated that the coating experienced some wear or ablation. Based on these Navy observations, the following analysis assumes that the zinc oxide is released through the ablative process similar to the baseline discharge discussion. As previously discussed in the baseline discharge discussion, solvents used in the coating to reduce viscosity during application are evaporated before the vessel is placed in the water.

Based on these assumptions and the equation in Section 2.1.1.2 for estimating release rates, the estimated release rates of constituents from the advanced antifouling coating *E Paint SN-1* are shown in Table 2-14.

Table 2-14. Release Rates for E Paint Company *E Paint SN-1*

Constituent	Release Rate [(µg/cm^2)/day]
Sea-Nine211® (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one)	1.8 [b]
Zinc oxide	17
Ethyl benzene[a]	0.0
Xylene[a]	0.0
Toluene[a]	0.0

[a]- VOCs are estimated to not be present in the cured coating.
[b]- Average leaching rate measured by ASTM Standard Test Method D 5108-90.

The biocide Sea-Nine211® exhibits a short half-life in the marine environment and degrades into less hazardous byproducts in less than one hour (Rohm and Haas, 2003). Due to the short half-life, studies showing the concentrations of Sea-Nine211® at varying distances from the hull were not available, because the product degrades before it can be sampled and the sample analyzed. To provide an estimate of the concentrations of Sea-Nine211® in the water around a ship, the assumption was made that that the Sea-Nine211® follows a similar diffusion pattern as the copper from a copper ablative coating. This assumption may result in an overestimate of concentrations; because copper is known as a persistent biocide, whereas Sea-Nine211® has a short half-life and is considered non-persistent.

Using the copper information presented in Section 2.1.1.2 and the known Sea-Nine211® release rate, concentrations at 1 cm and 35 m were estimated using the following formula:

$$\textit{Sea-Nine211}^{\circledR}\ \textit{Concentration at X m} = \left(\frac{\textit{Copper Conc. at Xm}}{\textit{Copper Static Release Rate}}\right) \times \textit{SeaNine}211\,\textit{Release Rate}$$

The concentrations estimated for Sea-Nine211® are presented in Table 2-15.

Table 2-15. Estimated Sea-Nine211® Concentrations

Distance	Concentration with Removal of Background Level (µg/l)
1 cm (End-of-Pipe)	1.0
35 m (Edge of Mixing Zone)	6.5×10^{-3}

Because it is assumed that zinc is also released in a manner analogous to copper from an ablative coating, total zinc concentrations were also calculated using the same approach. Table 2-16 shows the estimated total zinc concentrations.

Table 2-16. Estimated Total Zinc Concentrations

Distance	Concentration with Removal of Background Level (µg/l)
1 cm (End-of-Pipe)	10
35 m (Edge of Mixing Zone)	6.3×10^{-2}

Field Information

Field information was not collected as part of the UNDS program from ships coated with advanced antifouling coatings.

Descriptive Information

Descriptive information was not collected as part of the UNDS program for advanced antifouling coatings. As previously stated for copper-containing ablative coatings, hull coating leachate is not discharged from a pipe, but slowly released from the entire underwater hull of a vessel. In addition, constituent concentrations at the 35m edge of the mixing zone are estimated be negligible. Therefore, it is deduced that approved advanced antifouling do not produce a meaningful effect on color, floating materials, odor, settleable materials, taste, or turbidity/colloidal matter in receiving waters.

2.4.1.3 Discharge Generation Rates for Mass Loading

The following hypothetical analysis[1] is performed based on the ten vessels listed in the CVN 68 class. A complete list of Steel, Composite, and Other Non-Aluminum Rigid Hulls vessels is contained in the *Vessel Grouping and Representative Vessel Selection for Hull Coating Leachate Discharge* (EPA and Navy, 2003c). To estimate generation rates, all ten CVN 68 class vessels were considered. The release rate supplied by E Paint Company for Sea-Nine211® and the estimated release rate for zinc were used for all calculations. Table 2-17 presents the estimated generation rates for Sea-Nine211® and Table 2-18 presents the estimated generation rates for zinc for the CVN 68 vessel class assuming all vessels were coated with *E Paint SN-1*. A full listing of vessel classes and characteristics for calculating generation rates and mass loadings is included in Appendix B.

Table 2-17. CVN 68 Vessel Class Estimated Generation Rates for Sea-Nine211®

Class	Number of Vessels	Days In Port	Days in Transit (0-12 nm)	Days Underway (12+ nm)	Daily generation rate per vessel (kg Sea-Nine211®/day)			Annual generation rate per class (kg Sea-Nine211®/year)		
					In Port	Underway (0-12 nm)	Underway (12+ nm)	In Port	Underway (0-12 nm)	Underway (12+ nm)
CVN 68	10	147	3	215	2.7×10^{-1}	2.7×10^{-1}	2.7×10^{-1}	4.0×10^{2}	8.1	5.8×10^{2}

Note: This analysis includes the CVN 76 and CVN 77, neither of which is commissioned. The calculation does not account for a vessel's time in drydock.

[1] The calculations are hypothetical because *E Paint SN-1* is not approved for use on any Navy vessel.

Table 2-18. CVN 68 Vessel Class Estimated Generation Rates for Total Zinc

Class	Number of Vessels	Days In Port	Days in Transit (0-12 nm)	Days Underway (12+ nm)	Daily generation rate per vessel (kg Zn/day)			Annual generation rate per class (kg Zn/year)		
					In Port	Underway (0-12 nm)	Underway (12+ nm)	In Port	Underway (0-12 nm)	Underway (12+ nm)
CVN 68	10	147	3	215	2.5	2.5	2.5	$3.7x10^3$	76	$5.4x10^3$

Note: This analysis includes the CVN 76 and CVN 77, neither of which is commissioned. The calculation does not account for a vessel's time in drydock.

2.4.2 Uncertainty Information

While the E Paint Company claims that only Sea-Nine211® is released from *E Paint SN-1*, no data exist to support this claim. A registration letter from EPA provides the release rate for Sea-Nine211® but does not mention zinc. A representative of the company stated that zinc was a pigment encased in the resin and not released to the environment (E Paint, 2003a). EPA does consider zinc oxide to be a biocide in this formulation . The latest product data sheet on *E Paint SN-1* classifies the coating type as a copper and tin-free ablative matrix vehicle (E Paint, 2003b). Panels coated with the product are observed to wear or ablate in Navy tests suggesting the product does have ablative characteristics. There is uncertainty regarding the release rate of zinc from the *E Paint SN-1.* This analysis relies on the assumption that zinc is released at a rate proportional, by weight, to the release rate of Sea-Nine211®.

Seawater concentrations for Sea-Nine211® at varying distances from the hull were estimated assuming the constituents dilutes without degradation. This assumption introduces uncertainty because the Sea-Nine211® is known to have a short half-life in the marine environment. Therefore, this analysis used the conservative assumption that the Sea-Nine211® did not degrade in the marine environment.

Seawater concentrations for zinc at varying distances from the hull were estimated based on the assumption that zinc is released from the coating through the ablative process. Because the company claims that zinc is not released, the use of the ablative analysis introduces uncertainty. However, test panels coated with *E Paint SN-1* showed wear similar to ablative coatings and are the basis for the conservative assumption that the product is ablative (Lawrence, 2003).